JPPIPA 11(11) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Coffee Farmers' Adaptation to Climate Change in Pamatang Sidamanik (Case Study: Pamatang Sidamanik District, Simalungun Regency, North Sumatra)

Ramainim Saragih[1*], Andrian Yosia Marpaung[1], Jhonson A Marbun[1], Sry Artawati[1]

[1] Dosen Fakultas Pertanian, Universitas Simalungun, Pamatangsiantar, Indonesia.

Received: September 03, 2025
Revised: October 13, 2025
Accepted: November 25, 2025
Published: November 30, 2025

Corresponding Author:
Ramainim Saragih
saragihrama@gmail.com

DOI: 10.29303/jppipa.v11i11.13344

Abstract: This research is based on the fact that recently there have been frequent changes in weather compared to previous years, according to data from the Central Statistics Agency (BPS) of Simalungun Regency, it does not show major climate changes but has changed the perception of coffee farmers towards climate change in Pamatang Sidamanik District. This research was located in 3 villages in Pamatang Sidamanik District, namely Pamatang Sidamanik, Bandar Manik, and Sait buttu Saribu. The research method used was qualitative and quantitative, with data collection through questionnaires, interviews, and observations of 60 farmers selected purposively. Research data was measured using a Likert scale and analyzed using the Spearman correlation test and multiple linear regression. The results of this study are based on the frequency of farmers' perceptions, some farmers perceive changes in climate components as the same as before, although some farmers stated that there have been changes. When associated with climate components, it turns out that the perception of coffee farmers is that rainfall has increased, rainy days have increased, and minimum temperatures have increased. While maximum temperatures, air humidity, and sunlight intensity are moderate or the same as before. Mitigation measures as an effort to adapt to climate change by planting shade trees. Changes in all climate components are perceived to have a negative impact on coffee plants, for changes in air temperature, rainfall and rainy days are minimized through mitigation actions by farmers, while other climate components are not significant or real. The results of multiple linear regression analysis show that simultaneously the ratio of coffee plants to shade, fertilizer costs, labor costs and land area affect coffee farming income but partially only labor costs affect coffee farming income.

Keywords: Adaptation; Coffee Farmers; Climate Change; Mitigation actions; Perception

Introduction

In Indonesia, climate change is currently a serious challenge for the agricultural sector. Rising global temperatures, shifting rainfall patterns, and the increasing frequency and intensity of natural disasters such as floods, droughts, and extreme weather have significantly impacted agricultural productivity (Manalu, 2024). The Meteorology, Climatology, and Geophysics Agency (BMKG) noted that the average temperature in Indonesia is increasing by around 0.2 to 0.3 degrees Celsius per decade, with predictions that temperatures will continue to rise in the future. Coffee is

How to Cite:
Saragih, R., Marpaung, A. Y., Marbun, J. A., & Artawati, S. (2025). Coffee Farmers' Adaptation to Climate Change in Pamatang Sidamanik (Case Study: Pamatang Sidamanik District, Simalungun Regency, North Sumatra). *Jurnal Penelitian Pendidikan IPA*, *11*(11), 456–464. https://doi.org/10.29303/jppipa.v11i11.13344

a promising plantation commodity, and has long been a leading economic driver in Indonesia, boasting relatively high export figures. It not only serves as a source of income for the community but also serves as a source of foreign trade movement and revenue for the country (Ariyanti & Suryantini, 2019), coffee is a climate-sensitive crop (Bacon et al., 2017).

Climate change poses a real threat to the global agricultural sector, particularly in tropical countries like Indonesia. Coffee is a leading commodity that is vulnerable to changes in temperature, rainfall, and seasonal patterns. Coffee plants have a productive lifespan of 5 to 20 years. They possess strong roots that are resistant to climate change, particularly water availability, and tend to be drought-resistant. Although relatively resistant to drought and limited water availability, climate change, particularly drought due to the uncertain dry and rainy seasons, has a serious impact on coffee productivity. Unpredictable rainy seasons cause coffee plant flowers to fall off, causing the coffee cherries to fall off and rot, thus reducing coffee plant productivity (Mutolib et al., 2021).

Pamatang Sidamanik District in Simalungun Regency, North Sumatra, is known as a center for Arabica coffee production with ideal agro-climatic conditions. However, in recent years, farmers have begun to experience weather anomalies such as increasing minimum temperatures, high rainfall intensity, and an erratic planting season. Pamatang Sidamanik District's high altitude and evenly distributed rainfall throughout the year allow it to produce good quality coffee. This is evident in the number of residents in Pamatang Sidamanik who grow coffee as a supplementary income to meet their daily needs. According to data from the Central Statistics Agency (BPS) of Simalungun Regency, the climate in Pamatang Sidamanik District has not shown significant changes, but coffee farmers' perceptions of climate change have. Farmers' knowledge of climate change is a fundamental aspect in mitigating and adapting to climate change. Coffee farmers with a good understanding of climate change will strive to adapt to minimize its impact on coffee farming (Mutolib et al., 2021). Research related to the perceptions and mitigation strategies of climate change among coffee farmers has been conducted by Mutolib et al. (2021); Regita et al. (2025); Yuliasmara (2016), which shows that farmers have varying perceptions of climate change, and coffee farmers are more likely to adapt than to mitigate climate change.

Based on the above phenomenon, it is necessary to understand how coffee farmers perceive potential climate change, what adaptation measures they are taking to anticipate the impacts of climate change, and the impact of these adaptation measures on their income. Based on the above statement, this study aims to (1) analyze coffee farmers' perceptions of climate change in Pamatang Sidamanik District. (2) identify coffee farmers' cultivation practices as adaptations to climate change in Pamatang Sidamanik District. (3) analyze the impact of adaptation measures on coffee farmers' income in Pamatang Sidamanik District.

Method

This research was conducted in Pematang Sidamanik District, Simalungun Regency, North Sumatra Province. The research area, Pematang Sidamanik District, was selected purposively. This area is known as one of the coffee production centers in Simalungun Regency, North Sumatra, and its easily accessible location facilitated the author's research.

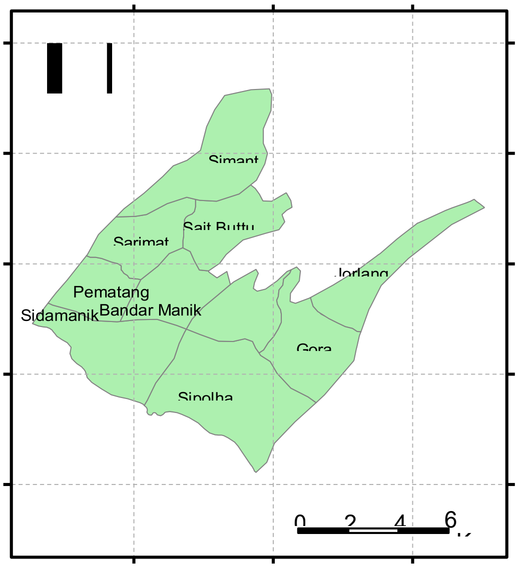

Figure 1. Map of research location

The population in this study was all coffee farmers in the Pamatang Sidamanik District. The sample was drawn using purposive sampling. Respondents were coffee farmers with more than five years of experience managing coffee plantations and residing in three villages selected based on data on the largest agricultural land area in the Pamatang Sidamanik District: Bandar Manik, Pamatang Sidamanik, and Sait Buttu Saribu. The target sample size was 60 people.

The data used included primary and secondary data. Primary data was obtained through direct interviews using questionnaires, while secondary data was obtained from relevant agencies, the Central Statistics Agency (BPS), literature, and other official documents. The main variables analyzed included: (a) farmers' perceptions of climate change; (b) farmers' adaptation actions and the relationship between these adaptation actions and their perceptions of the adverse impacts of climate change; and (c) coffee farming income.

Data analysis methods are a crucial part of data analysis, analyzing research data collected through various data collection techniques to generate conclusions and make decisions (Waruwu, 2024). Data analysis in this study was conducted both descriptively and quantitatively. Descriptive analysis was used to explain the characteristics of respondents, farmers' perceptions, and the forms of adaptation undertaken. The first analytical method for the formulation of the problem, regarding coffee farmers' perceptions of climate change, used data analysis with a perception index, measured using a Likert scale.

To explain the scores of respondents' answers, a total score was categorized for each indicator. To categorize the data obtained from the questionnaire, data tabulation was used. These indicators were then used as a starting point for developing an instrument, which could consist of questions. In this study, climate components were used as indicators, namely air temperature and rainfall. The assessment weights on the questionnaire scale are shown in the Table 1.

Table 1. Farmers' Perception Scale Points for Climate Change

Farmer Perception	Scores
Very High	5
High	4
Medium	3
Low	2
Very Low	1

Then the formula used to complete the Likert scale calculation is as follows Formula 1.

$$\text{Perception index} = \frac{total\ score}{Maximum\ score} \times 100\% \quad (1)$$

After calculating the food perception index formula, the results will be in the form of a percentage value on a Likert scale. The Likert scale coefficients are shown in Table 2.

Table 2. Likert Scale Coefficient

Value range %	Categories
0 - 20	Very low
21 - 40	Low
41 - 60	Medium
61 - 80	High
81 - 100	Very high

Spearman Rank correlation analysis was used to determine the relationship between farmer perceptions and adaptation actions, using equation 2.

$$rs = 1 - \frac{6\sum d^2}{n(n^2-1)} \quad (2)$$

Description:
rs = Spearman correlation coefficient
d^2= Squared ranking difference
n = Number of data/samples

Meanwhile, to test the effect of adaptation measures on income, multiple linear regression analysis was used:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 \quad (3)$$

Y = Income
X_1 = Fertilizer
X_2 = Labor
X_3 = Land area
X_4 = Comparison of the number of coffee plants with their shade
a = Constanta
b_1, b_2, b_3, b_4 = regression coefficient
X_1, X_2, X_3, X_4 = independent variable

Result and Discussion

Perception is the act of recognizing and interpreting sensory information to provide an overview and understanding of a particular environment. If a person's perception of something is positive, their perceived actions will usually be positive as well, and vice versa. Therefore, a person's perceptions, whether positive or negative, will influence their perceived actions (Fenko et al., 2018). Farmers' perceptions of climate change are the central focus of this research. This analysis can include their assessment of changes in temperature, rainfall patterns, and other changes that could impact coffee production.

Based on the Table 3, coffee farmers' perceptions of climate change in Pamatang Sidamanik District over a 10-year period are as follows: 21 coffee farmers agreed that rainfall had increased, and 24 agreed that increased rainfall would negatively impact coffee crops in Pamatang Sidamanik District; 31 coffee farmers agreed that the number of rainy days had increased, and 26 agreed that increased rainy days would negatively impact coffee crops in Pamatang Sidamanik District; 32 coffee farmers stated that maximum temperatures had neither increased nor decreased. 34 coffee farmers agreed that minimum temperatures had decreased or gotten colder. 32 coffee farmers agreed that the difference between maximum and minimum temperatures had increased. 43 coffee farmers agreed that increasing air temperatures could negatively impact coffee crops. 32 coffee farmers disagreed that there had been significant but moderate or normal changes in air humidity, and 30 coffee farmers agreed that increased humidity had negatively impacted coffee crops. 30 coffee farmers felt that the increase in wind intensity over the past 10 years had a normal or moderate perception, and 28 coffee farmers agreed that the increase in wind had a negative impact on coffee plants. 32 coffee farmers felt that the level of sunlight intensity had been normal over the past 10 years with no significant changes, and 33 coffee farmers felt that the increase in sunlight intensity could have a negative impact on coffee plants.

Table 3. Coffee Farmers' Perception Scores of Climate Change in Pamatang Sidamanik District

Climate components	Frequency of climate change perception					Frequency of climate change impacts				
	SS	S	SD	TS	STS	SS	S	SD	TS	STS
Rainfall increases	13	21	18	8	0	21	24	14	1	0
Rainy days increase	5	31	11	13	0	21	26	12	1	0
Air temperature:										
a. Maximum temperature increases	0	7	32	21	0	16	43	1	0	0
b. Minimum temperature decreases	8	34	11	7	0					
c. Difference between maximum and minimum temperatures increases	1	23	36	0	0					
Humidity increases	6	17	32	8	0	1	30	29	0	0
Wind increases	0	7	30	23	0	9	28	17	6	0
Sunlight intensity increases	0	3	32	25	0	0	18	33	9	0

The Table 4 shows that coffee farmers' perceptions of climate change are high (17 respondents), moderate (36 respondents), and low (7 respondents). Regarding the impact of climate change, 10 respondents perceived climate change as having a negative impact on coffee plants, with a very high (10 respondents), high (38 respondents), and moderate (12 respondents).

From observations and interviews with researchers, several coffee farmers stated that they believe the air temperature in Bandar Manik Village has increased significantly due to the expansion of oil palm plantations. Climate change is also evident in changes in the coffee plants. Several coffee farmers in Bandar Manik Village reported that their coffee cherries, which were still yellow, did not change color to red, but remained yellow and suffered damage, causing them to wilt and become unharvestable. This relates to research by Widayat et al. (2015), which states that climate change affects temperatures, leading to new pests and diseases that previously existed at lower elevations. Prolonged droughts have occurred. The shortening coffee harvest period results in increased harvesting costs, delayed fruit peeling, and over-fermentation, leading to lower quality. Changes in the rainy season, whether longer or shorter, and excessively high rainfall intensity, can lead to decreased coffee production due to disruptions to the coffee flowering system (Septiani & Kawuryan, 2021). Disruptions to the coffee flowering system result in the failure of coffee flowers to develop into fruit, impacting coffee farming productivity (Sakiroh et al., 2021; Sari et al., 2018).

Table 4. Frequency of Perceptions and Impacts of Climate Change

Types of perception	Categories					Total
	ST	T	S	R	SR	
Perception of climate change	0	17	36	7	0	60
Perception of the negative impact of climate change on coffee farming	10	38	12	0	0	60

From the explanation above, it can be concluded that Hypothesis 1, which states that most coffee farmers in Pamatang Sidamanik District perceive climate change, is not accepted. Some coffee farmers perceive no climate change or that the climate is the same as before. However, some farmers perceive that climate change has occurred. This is consistent with research conducted by Mutolib & Rahmat (2023), which found that 79% of coffee farmers agreed that climate change impacts seasonal changes. Identification of Mitigation Actions Undertaken by Coffee Farmers as Adaptation to Climate Change in Pamatang Sidamanik District.

Table 5. Frequency of Mitigation Actions for the Adverse Impacts of Climate Change on Coffee Farming

Climate components	Frequency of perception of adverse impacts of climate change	Mitigation measures	Frequency of climate change impact mitigation actions
Air temperature	High = 39	a. Shade plants	a. very high = 51
		b. Irrigation channels	b. very low = 40
		c. Pruning	c. high = 42
Rainfall	Very high = 45	a. Protective plants	a. very high = 45
		b. Drainage channels	b. low = 38
		c. Water reservoirs	c. low = 42
Rainy days	Very high = 45	a. Protective plants	a. very high = 45
		b. Drainage channels	b. low = 38
		c. Water reservoirs	c. low = 42
Sunlight intensity	High = 41	a. Protective plants	a. very high = 47
		b. pruning	b. high = 42
		c. artificial protection	c. low = 35
Air humidity	Medium = 32	a. Land clearing	a. very high = 37
		b. Pruning	b. high = 42
		c. Organic mulch	c. low = 44
Wind	Very high = 31	a. Protective plants	a. very high = 60
		b. Determining the location	b. low = 46
		c. Creating supports	c. very low = 33

Sixty coffee farmers have adopted adaptation measures by planting shade trees. Shade trees can reduce the intensity of direct sunlight hitting coffee plants, regulate the temperature around the coffee plants, increase humidity around the coffee plants, reduce soil erosion caused by rain or wind, and reduce strong wind speeds by absorbing and inhibiting wind flow. Types of shade trees planted by farmers include durian, jackfruit, avocado, lamtoro, petai, dadap, cinnamon, cloves, and sugar palm. Coffee planting patterns with shade are one of the things that can be implemented as an anticipatory measure against global warming (Yuliasmara, 2016). These various adaptation activities generally focus on changes in cultivation activities. Climate change adaptation technologies in coffee farming have been widely implemented, but to date there has been no detailed and specific study on the implementation of these adaptation technologies and the extent of their impact (Jawo et al., 2023; Kuhl, 2020; Pham et al., 2019; Verburg et al., 2019). Specifically for Indonesia, Syakir & Surmaini (2017) reported that the adoption rate of these various technologies at the farmer level is still very low. This condition is exacerbated by the limited access of most farmers to climate information, markets, technology, agricultural credit, and climate risk management information.

Furthermore, Gunathilaka et al. (2018) stated that the low adoption of adaptation technologies to climate variability and change in perennial crops is due to limited capital and access to short-term and long-term climate knowledge, as well as low support from the government and relevant stakeholders. Various studies have shown that climate affects coffee production, but the development of adaptation activities for coffee plants using climate forecasts has not been widely developed. This is in line with the results of a report Sarvina & Surmaini (2018) which stated that in general, the use of climate information for agriculture in Indonesia is still limited. Coffee farmers obtain information or knowledge regarding climate change adaptation and mitigation measures from various sources.

The knowledge and information obtained by coffee farmers in Pamatang Sidamanik District regarding adaptation or mitigation measures to the negative impacts of climate change on coffee plants is through agricultural extension workers, who provide technical guidance on adaptation strategies such as the use of cover crops, water management, and land conservation. Furthermore, farmers' experience in coffee farming is an important factor. This is because the more experience farmers have, the more knowledge they gain in farming (Dewi et al., 2017; Yulida, 2012). Farmer groups or associations of farmer groups are essential for farmers to discuss, share experiences, and participate in training related to climate change. Government institutions such as the Department of Agriculture also play an active role through training programs and assistance with agricultural production facilities that support adaptation. In some cases, family members with agricultural education backgrounds also serve as new information channels for farmers in dealing with the negative impacts of climate change (Wens et al., 2022). However, farmers' knowledge about climate remains low.

Spearman Rank Correlation Calculation Results: The Relationship Between Perceptions of the Adverse Impacts of Climate Change and Mitigation Actions

Correlation is a statistical technique used to test the presence or absence of a relationship and the direction of the relationship between two or more variables. The correlation coefficient indicates the strength of the relationship between two variables. The correlation coefficient value ranges from -1 to 1. If the correlation coefficient value is close to 1, the relationship between the two variables is very strong and positive. Conversely, if the correlation coefficient value is close to -1, the relationship between the two variables is very strong and negative. If the correlation coefficient value is close to 0, the relationship between the two variables is weak or there is no relationship at all. After testing, the results of the correlation test can be seen in Table 6.

Table 6. Spearman Rank Correlation Results between Perception and Adaptation

Variable	Rs	Significant	Information
Air temperature	0.832	0.000**	Very real
Rainfall	0.438	0.000**	Very real
Rainy days	0.438	0.000**	Very real
Sunlight intensity	0.159	0.225	Not real
Air humidity	-0.027	0.838	Not real
Wind	0.219	0.093	Not real

Based on the table above, it can be seen that three climate variables were found to be significant: air temperature, rainfall, and rainy days, while the other three were not. These relationships were based on farmer frequency. The explanation is as follows: The relationship between adaptation measures and the air temperature component (significance value 0.000 < 0.05), indicating that this relationship is statistically significant; The relationship between adaptation measures and the rainfall component (significance value 0.000 < 0.05), indicating that this relationship is statistically significant; The relationship between adaptation measures and the rainy days component (significance value 0.000 < 0.05), indicating that this relationship is statistically significant; the relationship between adaptation measures and the sunlight intensity component (significance value 0.225 > 0.05), indicating that this relationship is statistically insignificant; the relationship between adaptation measures and the air humidity component is statistically insignificant (0.838 > 0.05); and the relationship between adaptation measures and the wind component is statistically insignificant (0.093 > 0.05).

Analysis of the Impact of Adaptation Measures on Coffee Farmers' Income

Total Production Costs, Revenue, and Income

The Table 7 shows that the average coffee farmer's land area is 12.7 hectares, fertilizer costs are Rp. 641,000 per year, labor costs are Rp. 2,380,000 per year, and the average ratio of coffee plants to shade trees is 34, meaning that for every 34 coffee plants, there is one shade tree. The average annual income for coffee farmers in Pamatang Sidamanik District is Rp. 25,706,667. The average total production costs incurred by coffee farmers in running their farms are Rp. 3,443,100 per year. Therefore, the average annual income for coffee farmers in Pamatang Sidamanik District is Rp. 22,263,567.

Table 7. Average Land Area, Fertilizer Costs, Labor Costs, Difference in Coffee Plants with Shade, and Coffee Farmers' Income in Pamatang Sidamanik District in 2025

Type	Total amount (Rp)	Average (Rp)
Land Area	764	12.7
Fertilizer Cost	38,460,000	641,000
Labor Cost	142,800,000	2,380,000
Comparison of coffee plants with shade	2.055	34
Total production costs	234,446,000	3,443,100
Revenue	1,542,400,000	25,706,667
Income	1,335,814,000	22,263,567

Multiple linear regression to determine the effect of adaptation measures on coffee farmer income. Multiple linear regression to determine the effect of fertilizer, labor, land area, and the ratio of coffee plants to shade on coffee farmer income in Pamatang Sidamanik District. Further analysis of the variables influencing coffee farmer income can be seen in the Table 8.

Table 8. Multiple Linear Regression Analysis of the Effect of Fertilizer, Labor, Land Area, and Shade Crops on Coffee Farmer Income

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-35444819.221	4523490.808		-7.836	0.000
	fertilizer costs	-.322	1.096	-.011	-0.294	0.770
	labor costs	20.394	3.054	.777	6.678	0.000
	land area	528887.589	344241.490	.178	1.536	0.130
	coffee shade ratio	135055.148	258901.566	.027	0.522	0.604

a. Dependent Variable: pendapatan

Coefficient of Determination (R2)

The coefficient of determination explains the relationship between the independent variable and the dependent variable. The coefficient of determination can be seen in Table 9.

Table 9. Results of the Determination Test (R2)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.965[a]	0.930	0.925	4543915.131

Based on the table above, the R2 (R Square) value is 0.930. This indicates that the independent variables (fertilizer, labor, land area, and shade) contribute 93.0% to the dependent variable (coffee farmer income), while the remaining 7.0% is influenced by other variables not included in this model.

Simultaneous Regression Coefficient Test (F-Count)

The F-test in multiple linear regression analysis aims to determine the simultaneous influence of independent variables.

Table 10. Results of the Simultaneous Regression Coefficient Test (F-Count)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15159222539337440.000	4	3789805634834361.000	183.551	0.000[b]
	Residual	1135594059395892.000	55	20647164716288.953		
	Total	16294816598733330.000	59			

Based on the statistical test results, the calculated F value was 183.551 with a sig value of 0.000. Since the sig value of 0.000 is <0.05, and the calculated F value of 183.551 > Ftable = 2.54, it can be concluded that Ho is rejected and H1 is accepted, indicating a simultaneous influence between the variables of fertilizer, labor, land area, and shade on income (Y).

Partial Regression Coefficient Test (T-test)

The T-test was used to examine the effect of the variables of fertilizer, labor, land area, and shade on the dependent variable (income) partially. This test was conducted to determine the significance of each independent variable on coffee farmers' income using a significance level of <0.05.

Results of the Partial Regression Coefficient Test (T-test): the effect of fertilizer Costs (X1) on coffee farmers' income. The sig value is known. The partial effect of X1 on Y is 0.770 > 0.05. Therefore, it can be concluded that H0 is accepted and H1 is rejected, meaning that fertilizer costs have no significant effect on coffee farmers' income (Y). The negative coefficient for fertilizer indicates that the effect of fertilizer on income is negative; The effect of labor costs (X2) on coffee farmers' income

The sig. value for the partial effect of X2 on Y is 0.000 < 0.05. Therefore, it can be concluded that H0 is rejected and H1 is accepted, meaning that labor costs have a significant effect on coffee farmers' income (Y). The positive coefficient for labor indicates that the effect of labor on income is positive. If labor costs are increased by Rp. 1, income will increase by Rp. 20,394.

The Effect of Land Area (X3) on Coffee Farmers' Income. The sig. value for the partial effect of X3 on Y is 0.130 > 0.05. Therefore, it can be concluded that H0 is accepted and H1 is rejected, meaning that land area has no significant effect on coffee farmers' income (Y). The positive sign for land area indicates a positive effect on income.

The Effect of the Ratio of Coffee Plants to Shade Trees (X4) on Coffee Farmers' Income. The significant value for the partial effect of X4 on Y is 0.604 > 0.05. Therefore, it can be concluded that H0 is accepted and H1 is rejected, meaning that shade trees have no significant effect on coffee farmers' income (Y). The positive sign for shade indicates a positive effect of shade trees on income.

Low coffee productivity is a major problem in Indonesia's coffee production system. Hafif et al. (2014) stated that most coffee in Indonesia is still cultivated traditionally, characterized by the dominant use of local clones with low productivity and inadequate maintenance. Coffee farmers only visit the plantations during planting and harvesting times. Furthermore, Byrareddy et al. (2019) reported that most coffee in Indonesia fails to reach its potential production due to very low fertilizer doses, or even no fertilizer application at all. Neilson (2013) stated that climate factors are another contributing factor to low coffee productivity in Indonesia.

Conclusion

The results of this study are based on the frequency of farmer perceptions, some farmers perceive changes in climate components as the same as before, although some farmers stated that there have been changes. When associated with climate components, it turns out that coffee farmers' perceptions are that rainfall has increased, rainy days have increased, and minimum temperatures have increased. While maximum temperature, air humidity and sunlight intensity are moderate or the same as before. The results of this study indicate that coffee farmers are taking mitigation measures as an effort to adapt to climate change by planting shade trees. Changes in all climate components are perceived to have a negative impact on coffee plants, for changes in air temperature, rainfall and rainy days are minimized through mitigation actions by farmers, the correlation value (rs) between the perception of the negative impacts of climate change can be minimized through mitigation actions with mitigation actions carried out by farmers are all significant (0.000 <0.05 alpha value), while other climate components are not significant or real. The results of multiple linear regression analysis show that simultaneously the ratio of coffee plants to shade, fertilizer costs, labor costs and land area affect coffee farming income while partially only labor costs affect coffee farming income..

Acknowledgments
The author team would like to thank all parties involved in this research directly or indirectly so that this research can produce published article output.

Author Contributions
This article was written by four authors, namely, R. S., A. Y. M., J. A. M., and S. A. All authors have an equal contribution in carrying out each stage of the research.

Funding
The authors declare no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Ariyanti, W., & Suryantini, A. (2019). Usaha tani kopi robusta di Kabupaten Tanggamus: Kajian strategi pengembangan agrobisnis. *Jurnal Kawistara*, *9*(2), 179–191. https://doi.org/10.22146/kawistara.40710

Bacon, C. M., Sundstrom, W. A., Stewart, I. T., & Beezer, D. (2017). Vulnerability to cumulative hazards: Coping with the coffee leaf rust outbreak, drought, and food insecurity in Nicaragua. *World Development*, *93*, 136–152. https://doi.org/10.1016/j.worlddev.2016.12.025

Byrareddy, V., Kouadio, L., Mushtaq, S., & Stone, R. (2019). Sustainable production of robusta coffee under a changing climate: A 10-year monitoring of fertilizer management in coffee farms in Vietnam and Indonesia. *Agronomy*, *9*(9), 499. https://doi.org/10.3390/agronomy9090499

Dewi, N., Utama, M. S., & Yuliarmi, N. N. (2017). Faktor-faktor yang mempengaruhi produktivitas usaha tani dan keberhasilan program simantri di Kabupaten Klungkung. *E-Jurnal Ekonomi Dan Bisnis Universitas Udayana*, *6*(2), 701–728. Retrieved from https://shorturl.asia/ig4Wm

Fenko, A., De Vries, R., & Van Rompay, T. (2018). How strong is your coffee? The influence of visual metaphors and textual claims on consumers' flavor perception and product evaluation. *Frontiers in Psychology*, *9*, 53. https://doi.org/10.3389/fpsyg.2018.00053

Gunathilaka, R. P. D., Smart, J. C. R., & Fleming, C. M. (2018). Adaptation to climate change in perennial cropping systems: Options, barriers and policy implications. *Environmental Science \& Policy*, *82*, 108–116. https://doi.org/10.1016/j.envsci.2018.01.011

Hafif, B., Prastowo, B., & Prawiradiputra, B. R. (2014). Pengembangan perkebunan kopi berbasis inovasi di lahan kering masam. *Pengembangan Inovasi Pertanian*, *7*(4), 199–206. Retrieved from https://shorturl.asia/NLs4y

Jawo, T. O., Kyereh, D., & Lojka, B. (2023). The impact of climate change on coffee production of small farmers and their adaptation strategies: a review. *Climate and Development*, *15*(2), 93–109. https://doi.org/10.1080/17565529.2022.2057906

Kuhl, L. (2020). Technology transfer and adoption for smallholder climate change adaptation: opportunities and challenges. *Climate and Development*, *12*(4), 353–368. https://doi.org/10.1080/17565529.2019.1630349

Manalu, S. (2024). Dampak Perubahan Iklim Terhadap Produksi Pertanian di Indonesia. *Literacy Notes*, *2*(1). Retrieved from https://shorturl.asia/nQ2i3

Mutolib, A., & Rahmat, A. (2023). Sikap petani kopi robusta terhadap perubahan iklim di kecamatan air hitam kabupaten lampung barat. *Jurnal Education and Development*, *11*(3), 100–105. https://doi.org/10.37081/ed.v11i3.4934

Mutolib, A., Rahmat, A., & Sumiati, T. (2021). Pengetahuan dan Adaptasi Petani Kopi terhadap Perubahan Iklim di Kecamatan Air Hitam Kabupaten Lampung Barat. *Universitas Siliwangi*, *6*(4). Retrieved from https://shorturl.asia/tNeIh

Neilson, J. (2013). The value chain for Indonesian coffee in a green economy. *Buletin Ristri*, *4*(3), 183–198. Retrieved from https://shorturl.asia/p6l9I

Pham, Y., Reardon-Smith, K., Mushtaq, S., & Cockfield, G. (2019). The impact of climate change and variability on coffee production: a systematic review. *Climatic Change*, *156*(4), 609–630. https://doi.org/10.1007/s10584-019-02538-y

Regita, A. P. T., Zainuddin, A., Rondhi, M., & Utami, R. A. (2025). Persepsi dan Mitigasi Petani Kopi Robusta Terhadap Dampak Perubahan Iklim: Sebuah Analisis Deskriptif. *Agrimics Journal*, *2*(1), 37–49. https://doi.org/10.64118/aj.v2i1.38

Sakiroh, S., Rokhmah, D. N., & Supriadi, H. (2021). Potensi keberhasilan pembentukan buah lima klon kopi robusta. *Vegetalika*, *10*(3), 204–213. https://doi.org/10.22146/veg.61350

Sari, P. A., Suryana, U., & Hedismarlina, M. (2018). *Analisis permasalahan petani tanaman Kopi Rakyat di Pangalengan dengan mengadaptasi Theory of Change*. Retrieved from http://repository.ekuitas.ac.id/handle/123456789/425

Sarvina, Y., & Surmaini, E. (2018). Penggunaan Prakiraan Musim untuk Pertanian di Indonesia: Status Terkini dan Tantangan Kedepan. *Jurnal Sumberdaya Lahan*, *12*(1), 33–48. Retrieved from https://shorturl.asia/EywTa

Septiani, B. A., & Kawuryan, I. S. S. (2021). Analisa Penyebab Turunnya Produksi Kopi Robusta Kabupaten Temanggung. *EKUITAS (Jurnal Ekonomi Dan Keuangan)*, *5*(3), 365–388. https://doi.org/10.24034/j25485024.y2021.v5.i3.4612

Syakir, M., & Surmaini, E. (2017). Perubahan iklim dalam konteks sistem produksi dan pengembangan kopi di Indonesia. *Jurnal Penelitian Dan Pengembangan Pertanian*, *36*(2), 77–90. https://doi.org/10.21082/jp3.v36n2.2017

Verburg, R., Rahn, E., Verweij, P., Van Kuijk, M., & Ghazoul, J. (2019). An innovation perspective to climate change adaptation in coffee systems. *Environmental Science & Policy*, *97*, 16–24. https://doi.org/10.1016/j.envsci.2019.03.017

Waruwu, M. (2024). Metode penelitian dan pengembangan (R&D): konsep, jenis, tahapan dan kelebihan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(2), 1220–1230. https://doi.org/10.29303/jipp.v9i2.2141

Wens, M. L. K., Van Loon, A. F., Veldkamp, T. I. E., & Aerts, J. C. J. H. (2022). Education, financial aid, and awareness can reduce smallholder farmers' vulnerability to drought under climate change. *Natural Hazards and Earth System Sciences*, *22*(4), 1201–1232. https://doi.org/10.5194/nhess-22-1201-2022

Widayat, H. P., Anhar, A., & Baihaqi, A. (2015). Dampak perubahan iklim terhadap produksi, kualitas hasil dan pendapatan petani kopi arabika di Aceh Tengah. *Jurnal Agrisep Unsyiah*, *16*(2), 8–16. https://doi.org/10.24815/agrisep.v16i2.3041

Yuliasmara, F. (2016). Strategi mitigasi perkebunan kopi menghadapi perubahan iklim. *Warta Pusat Penelitian Kopi Dan Kakao*, *28*(3), 1–7. Retrieved from https://shorturl.asia/go3kj

Yulida, R. (2012). Persepsi Petani Terhadap Usahatani Lahan Pekarangan (Studi Kasus Usahatani Lahan Pekarangan di Kecamatan Kerinci Kabupaten Pelalawan). *Indonesian Journal of Agricultural Economics*, *3*(2), 9043. Retrieved from https://shorturl.asia/0fVJs